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BIOCHARACTERS AS SEPARABLE UNITS OF ORGANIC STRUCTURE

HENRY FAIRFIELD OSBORN

INTRODUCTION

As to the term "character," in the commonly accepted sense of zoology and botany, it has long been known that different characters, large and small, exhibit different rates of evolution and are in this sense "separable" or "independent," while in another sense it has long been known that every character of an organism is correlated or coordinated with every other character in function and adaptation. Our general knowledge of character separability (for the want of a better English term) has been more than confirmed by researches based upon the great discovery of Mendel, namely, that many large as well as minute characters which are closely associated or even blended in the adult organism are very sharply separated from each other in the germ plasm, in such a manner that they may entirely appear or disappear in the crossing, or hybridization of species, subspecies, varieties, races, no less than of individuals. The theoretic separability in heredity of the germinal "determiners" or "factors" of characters is in full accord with the several aspects of separability in evolution previously observed in paleontology, embryology and individual development.

The purpose of this synopsis is to review and bring together some of the noteworthy phenomena of character separability as contrasted with those of interdependence, cooperation, correlation and coordination.

It is probable that this principle of separability of units of function and structure, which has been discovered in so many processes of the organism, will prove to be a universal principle. This principle is more or less a necessary consequence of the unit-cellular structure of the organism; if instead of being composed of cell units, each possessing its peculiar heredity qualities, an organism were composed of fluid or solid masses of different kinds, we can not imagine how it could split up into character units. Yet the cell is probably not the ultimate, or least character unit, which is doubtless a chemicophysical unit. This is extremely suggestive in connection with our conceptions of the nature of the evolution process, for the process more or less clearly resolves itself into three problems, namely: (1) how do these character units arise; (2) how are these character units coordinated into harmonious action within the organism; (3) why do these character units independently evolve, progress or retrogress?

Since the word "character" is very vague, and since the term "unit character" has a special and limited meaning in Mendelian heredity, I propose the new term "biocharacter" as a general designation of the character unit in the organism.

1. KINDS OF BIOCHARACTERS OBSERVED IN PALEONTOLOGY

Biocharacters are those characters, large and small, which through the evidence afforded by ontogeny (*i. e.*, zoology, embryology), phylogeny (*i. e.*, paleontology), or heredity (Mendelian inheritance) are found to be separable from or independent of each other as units in the processes of heredity, of evolution, and of individual development.

Paleontology gives evidence no less positive than embryology and experimental heredity that each organism is made up of a number of such separable characters, including those known as the "unit characters" of Mendelian heredity. In paleontology this separability in heredity and evolution is found to apply to structural, or anatomical, characters of three principal kinds, namely, I, II, III:

I. *New orthogenetic characters (rectigradations of Osborn), characters having an adaptive evolutionary direction from the start, completely separable in heredity, so far as observed continuous in origin.*	II. *New numerical characters, presence and absence characters, meristic characters, characters either adaptive or non-adaptive, completely separable in heredity, so far as observed discontinuous in origin.*	III. *New proportional characters (allometrons of Osborn), quantitative and intensive characters. Generally separable, sometimes blending in heredity, so far as observed continuous in origin, adaptive or neutral.*
Examples	*Examples*	*Examples*
New horns, germinal separability. New dental cusps, germinal separability. Certain new dental folds and plications, germinal separability. Such rectigradations are relatively rare in titanotheres, and much more prevalent in the teeth of horses.	Such characters are of three kinds: (1) Abnormal, or teratological, i. e., reduplication of parts already present, supernumerary digits, teeth, vertebræ, ribs, etc.; (2) normal, by added vertebræ, added ribs, added teeth, added phalanges; (3) minute saltations of structure, minor variations of Darwin.	Variations in size and proportions of existing units of structure, i. e., evolution of skull and limb proportions, dolichocephaly, brachycephaly, platycephaly, dolichodactyly, brachydactyly; in brief, adaptive changes of proportion and intensity in existing characters and groups of characters.
	Evolution through the multiplication or diminution of existing parts.	

The property of separability, divisibility, independence of these biocharacters stands in contrast to that of their interdependence and coordination of function in the organism. As remarked above the discovery of this property of separability of characters was gradually prepared for in various branches of biology. First, in comparative anatomy, through the observations of the laws of independent degeneration, balance and progression of adjoining parts; second, through embryogeny and ontogeny, in the observation of the hastened or retarded development of adjoining parts; third, through heredity, as, for example, in the mosaic inheritance of Galton; fourth, through paleontology and phylogeny, in the law of acceleration and retardation of Hyatt and, through the observations of many other paleontologists, concluding with the detailed observations of Osborn and Gregory. But the property of separability first shone out clearly and most brilliantly in the discoveries of Mendel in heredity.

This property of structural separability and independence of evolution is closely connected with *separability or independence of function.* Thus separability may distinguish a great number of cells and tissues which are united by a single function, or separability may distinguish a single cell, as, for example, the single giant cells of the spinal cord of certain fishes and amphibians.

It is important, therefore, to realize that this property of separability, the separability of biocharacters, is now observable under six classes of evidence.

2. MODES OF SEPARABILITY OF BIOCHARACTERS IN HEREDITY, IN GENESIS, IN RATE OF EVOLUTION

I. *Biocharacter heritage separability,* unit or exclusive inheritance.
    1. *Evidence of Galton, etc., as to mosaic inheritance.*
    2. *Character heritage separability,* under the separate "determiner" or "factor" hypothesis of Mendel, Bateson, Morgan, etc., according to which each "biocharacter" of the soma may spring from one or more "determiners" or

  "groups of determiners" in the germ. Many characters are not entirely separable, but tend to go in groups or to blend.
  3. *Character heritage blending,* Castle, Osborn, etc., as observed in color, size, proportion, etc.

II. *Separability in genesis, biocharacter origin and evolution.*
  1. *Origin through saltation,* large heritable leaps (*saltus,* a leap, syn. discontinuity, Bateson).
  2. *Origin through minute heritable gradations* (*gradus,* a step), Darwin (minute heritable variations), De Vries (mutations).
  3. *Origin through continuity* (*continuatio,* an unbroken series; continuous describes that which is absolutely without pause or break, in contrast to saltation = leaps, gradation = steps). It has been shown (Osborn) that characters continuous in origin may be separable or discontinuous in heredity, as in both the new rectigradations and new proportion characters of the hybrid of the horse and the ass.
  4. *Continuous rectigradations,* Osborn, *i. e.,* orthogenetic or adaptive origin followed by adaptive evolution in a single direction, a principle probably corresponding with the *Mutationsrichtung* of Neumayr.
  5. *Homomorphic* (Fürbringer) *rectigradations, through independent origins,* the independent production of similar biocharacters in organisms of similar ancestral affinity, the "potential homology" of Osborn, as distinguished from the true homogeny, homology *sensu strictu,* of direct descent of characters from each other.
  6. *Mutations of Waagen,* subspecific steps or gradations in evolution of characters under the *mutationsrichtung,* or trend of development in certain directions, of subspecific value, *i. e.,* intergradations between species.

III. *Separability in velocity, biocharacter motion* (*i. e.*, rate of transformation, or relative displacement).

1. *Ontogenetic acceleration*, hastening of development in ontogeny, resulting in certain biocharacters appearing at earlier and earlier stages of development. Hyatt's law.
2. *Ontogenetic retardation*, slowing down of biocharacters in ontogeny, resulting in certain biocharacters appearing at later and later stages of development. Hyatt's law.

   1 and 2 result in heterochrony (Gegenbaur).
3. *Ontogenetic balance*, resulting in biocharacters appearing at the same stage as in the ancestral forms.
4. *Phylogenetic acceleration*, appearance of certain homomorphic biocharacters at earlier geologic periods in some phyla than in others.
5. *Phylogenetic retardation*, whereby some homomorphic biocharacters appear at later geologic periods in some phyla than others.
6. *Phylogenetic balance.*

IV. *Separability in grouping, biocharacter cooperation and coordination.*

A biocharacter may be closely linked with others in group function or it may detach itself and connect with another group, *e. g.*, color and speed biocharacters in horses.

1. *Biocharacter correlation into similar adaptive character groups.*
2. *Biocharacter grouping through heredity*, attributable to prolonged ancestral grouping.
3. *Biocharacter compensation*, the gain of one character at the expense of another. The law of compensation of St. Hilaire.
4. *Biocharacter sex linkage*, the union of groups of characters with the function of sex as family or secondary sexual characters.

V. *Separability in proportion characters. Character proportion genesis, separability in the evolution and heritage of proportions.*

1. *Proportion genesis through fluctuation,* theoretically through continued selection of plus and minus variations in a given direction in cases where such variations of proportion are of adaptive significance, as in fluctuating variations of length of neck in the giraffe.
2. *Character proportion continuity in zoologic and paleontologic series,* the unbroken succession in the evolution of changes of proportion, as in brachycephaly and dolichocephaly in kindred races of man.
3. *Character proportion saltation, in hybrids only,* sudden appearance of profound changes of proportion, as in the Mouchamp breed of sheep.
4. *Character proportion heritage separability.* Complete separation in heredity of certain proportional characters, as in crosses between dolichocephalic and brachycephalic types in man.
5. *Character proportion heritage blending,* the origin of blended, or intermediate, forms of certain proportional characters in man and horses.
6. *Character proportion genesis,* partly at least through interaction of separably specific harmones, chalones, internal messengers of the thyroid and other internal secreting glands.

VI. *Separability in orthogenesis, rectigradations, genesis of new adaptive characters from infinitesimal beginnings.*

1. *Independent genesis of similar adaptive characters* in different phyla giving rise to homomorphy.

2. *Evidence of hereditary predetermination or potentiality* of the genesis of similar new characters in phyla derived from similar ancestors.
3. *Continuous evolution of rectigradations in one direction, Mutationsrichtung.*
4. *Mutations of Waagen,* subspecific gradations of character.
5. *Complete separability of rectigradations in heredity,* as shown in the teeth of the hybrids of the horse and ass, all rectigradations being either present or absent but not blended.

3. SUMMARY

It appears from the foregoing classes of evidence that biocharacters are separable in origin, development, evolution, and heredity. First, biocharacters are separable through their many different modes of origin from the germ, either saltatory, gradational, or continuous. Second, biocharacters have different rates of motion, or velocity, in individual development (ontogeny), exhibiting acceleration or retardation. Third, biocharacters have different rates of evolution in different phyla (phylogeny), again exhibiting acceleration or retardation (phyla). Fourth, all the biocharacters of an organism cooperate through various modes of grouping in functional correlation, in compensation, in sex linkage. Fifth, in the hard parts of the body while the biocharacters of form and proportion may originate through continuity, through saltation, or through minute gradations, all the known evolution of proportion biocharacters is continuous. Sixth, in the hard parts the biocharacters of rectigradations have only been observed to originate and develop through continuity.